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– Atal Behari Vajpayee

The Prime Minister of India with 'Kids for Tigers'
– New Delhi, January 18, 2002.

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Foreword

This booklet could not have been better timed. For it comes to you in 2003, declared by the United Nations as the International Year of Freshwater. This is the opportunity to focus our energies on protecting, indeed respecting, our water resources on every level: individual, community, regional, national, and global.

But isn't it ironic that there have to be international declarations for us to realize the significance of water and, more so, of the damage we are causing it through our reckless, thoughtless acts? Did we not learn when cool water trickled down our throats and splashed onto our flushed faces, erasing all the fatigue of a blistering summer day? Did we not gaze awestruck when the mighty monsoon pelted down raindrops, hail, sleet, and snow to sink into the earth and help the flowers of the coming spring blossom in millions of hues?

Water is the elixir of life, they say. Yet, we now hear of pesticides in drinking water, arsenic poisoning of groundwater, and similar threats to human health and well-being due to polluted water bodies. Oil spills are devastating ocean ecosystems, choking thousands of species into extermination. Look closer...where does the garbage in my house and office end up? Do I flood my garden or hose down my car with bucketful of fresh water? Has the thought of harvesting rainwater crossed my mind? Will I ever learn?

This booklet hopes to initiate a learning process in the young minds of today, who will hopefully grow into conscious and conscientious citizens of tomorrow. It covers the entire gamut of issues: water sources; how they get polluted, contaminated, or depleted; how that impacts on human and ecosystem health; how we can conserve water... Interesting snippets and stories are liberally sprinkled throughout. Children can gain an insight into global initiatives on water and understand India's policy as well.

I would like to thank the TERI team for its research and production of this handy document, which we hope will prove useful in enhancing awareness and knowledge in the field of water. I would also like to take this opportunity to appeal to readers to send in their comments.

(S K Alagh)
Managing Director and CEO
Britannia Industries Limited

Foreword

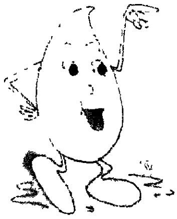
It has now become almost fashionable for glib statements to be made that the next World War, if any, would take place over water. This is an unfortunate dramatization of a danger that is likely to affect the lives of billions of people in the future who would suffer extreme privation due to lack of adequate clean water. The issues of clean water and sanitation are closely interlinked. Already 2.4 billion people, representing more than one-third of the global population, have no access to proper sanitation. As a result, 2.2 million people die annually from diseases associated with poor water and sanitary conditions. Even more tragic is the fact that 6000 children die everyday from diseases that can be prevented through improvements in water supply and provision of sanitation facilities.

All of this represents an ironic reality. Most regions in the world still have adequate water to meet the needs of people who depend on it. Unfortunately, water remains perhaps the most mismanaged resource on the planet. Large quantities of water throughout the world are wasted or used inefficiently with demand rising faster than the supply that can be replenished by nature. The balance, therefore, has to be restored through substantial improvements in the management of this resource. Water use increased six-fold during the last century, more than twice the rate of population growth, while illegal water hook-ups and waste totalled approximately 50% of the quantity of water used for drinking in developing countries. There is clearly a need for those of us living in developing societies to change our attitudes towards the management and use of water in our everyday lives.

The one section of society in India, for instance, that can make a difference in this regard is the increasingly sensitive population of the young, whose awareness and involvement related to natural resource management and environmental issues represents enormous hope. It is, therefore, important for those of us working on natural resource management issues to provide facts, perspectives, and knowledge that would bring about a more responsible approach to management of water in this country, and there is no better audience to address on this subject than the increasingly responsible tens of millions of schoolchildren throughout India.

This book represents a modest, but hopefully effective, effort in this direction. Symbolizing the spirit of partnership that is essential for solving the major social problems of this planet, this book has been sponsored by Britannia Industries Ltd, because corporate social responsibility and enlightened business interest requires companies to get involved in such efforts in partnership with other stakeholders. We hope that this attractively produced publication will prove to be a small, yet effective, step in bringing about better management of water resources in India.

(R K Pachauri)
Director-General, TERI



Introduction

The ability to see, hear, and speak is useless in the absence of adequate water. Water is the basis of life. Most life forms are born in water and live in it. O water stream come near me. You are the elixir of immortality.

Atharvaveda, 3:13:6

Human existence, since time immemorial, has centred around water. Most ancient civilizations grew along the banks of rivers. Agriculture was the main occupation and the fields were irrigated using nearby sources of freshwater. The annual flooding of rivers in India and other parts of the world left behind soil rich in nutrients, which helped agriculture. This ensured the survival and growth of these civilizations. Besides providing drinking water, rivers also served as highways that enabled boats and ships to ferry goods and people. Thus, rivers formed the very basis of life.

Compare this . . .

If a large bucket of water were to represent the sea water, an eggshell would represent the water in the ice caps and glaciers, and a teaspoonful would be the total quantity of drinking water available.

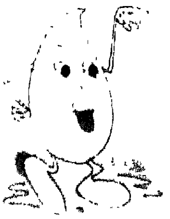
Viewed from space, the Earth looks mostly blue. This is because about 70% of its surface is covered with water. When you look around, you see water in lakes, rivers, streams, and of course, in the seas and oceans. There is water in the air also in the form of water vapour, and in the ground as soil moisture and groundwater.

About 97% of all water is saline, 2% is freshwater but is locked in the form of ice caps, glaciers, icebergs, and in the air. Only 1% can be drunk.

Water is composed of hydrogen and oxygen – two hydrogen atoms linked to one atom of oxygen by a single chemical bond – H_2O. It is odourless, colourless, and tasteless. It has a freezing point of 0 °C (32 °F) and a boiling point of 100 °C (212 °F).

People can survive without food for days but cannot survive without water. Millions of tonnes of water are required daily for agriculture, industry, washing, drinking, and other purposes. In many parts of the world, people have to walk for miles to get drinking water.

Let us follow the winding trail of water as it flows along its course through the living and non-living world, changing form, and bringing changes to the lives of all beings on Earth.



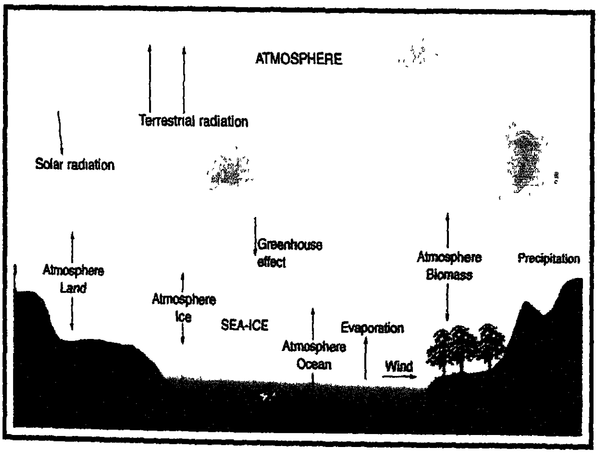
Water: the elixir of life

Even the wealth of the wide sea would be diminished, if the cloud that has drawn its waters up, gives them not back again.

Thirukkural – ancient Tamil text

Water is continuously moving – on the surface of the Earth, in the air, and below the ground – and constantly changing its form. It evaporates from land and water bodies and also emerges from all forms of life on Earth. This water vapour moves through the atmosphere, condenses to form clouds, and falls as rain and snow. In time, the water returns to where it came from, and the process begins all over again. The water or hydrological cycle helps to move water from one part of the world to another. The Sun plays a very important role in this cycle. Although water is constantly moving, its total quantity on Earth's surface is constant. The same amount of water that existed in the Earth's system millions of years back, exists today.

Reference to the hydrological cycle has been made in many ancient texts including the *Vedas*. The *Arthashastra*



Activity

understanding the water cycle

What image comes to your mind when you read about the water cycle? A cyclic flow of water from one source to another? Well, if you think so, you are wrong! Because the water cycle is much more than a ride around in a circle. A lot of interactions and multidirectional flows govern the movement of water.

Group size Ideal for a group of 15–20 students.

Requirements Cards, yarn, and ENTHUSIASM...

How to begin the activity Prepare cards for various components and factors that exist in the water cycle: clouds, rain, snow, puddle, Sun, etc.

How to play Distribute the cards to the group so that each person has at least one. Give the yarn to the child who has the card called 'cloud'. Allow this child to be the group leader. She or he will decide to whom the yarn goes next. And, watch the water cycle develop!

Hint The 'cloud' can hand the yarn to 'rain'. And from rain it can go to 'fields', 'groundwater', and so on. Continue throwing the yarn from person to person. A web will form. This activity demonstrates that the water cycle is not a circle, but that water goes to and fro, up and down, and may take many routes before it completes a full cycle. This activity also gives students a chance to reinforce the vocabulary associated with the water cycle.

of Kautilya (400 BC) and *Astadhyayi* of Panini (700 BC) refer to the rain gauge and also reveal a knowledge of the quantity of rainfall in various parts of India.

Forms of water

Water is found in three different forms – liquid, solid, and gas – depending on the temperature. Remember, though, that water is constantly changing from one form to another. The temperature of a place decides which of these forms is predominant in a particular area.

Liquid

Water is usually found in the liquid state, because this is its natural state when temperatures are between 0 °C and 100 °C.

Rain—recycled water

The *average* rainfall across the entire surface of Earth is about 85 cm (or just under 34 inches). Of course, we know that some areas get much more rain than this, while others hardly get any rain at all. But the amazing thing is that if all the water vapour in all the clouds in the sky could be instantly turned into rain, it would make a global layer of water only 2.5 cm (barely one inch) thick! And if all this rainwater ended up in the oceans, the sea-level would rise by just 3.5 cm! So, where on Earth (if you'll pardon the expression) does that 85 cm of worldwide average annual rain come from?

The answer is recycling! Water evaporates from lakes, rivers, and oceans as fast as it falls as rain, replenishing the humidity of the atmosphere. The global average annual rainfall of 85 cm represents 34 times more water than there is present in the atmosphere at any given point of time (2.5 cm rain). So, we can roughly say that it takes water 1/34th of a year - or just under 11 days - to complete the cycle of evaporation and rainfall! However, if the overall temperature of Earth changes significantly, the amount of water that the atmosphere can hold, and hence the amount of rainfall, changes accordingly. This is what happened during the last Ice Age: there was less evaporation, the air was drier, and so there was less rain.

In regions of young volcanic activity, hot water emerges from the Earth in liquid form; such places are called hot springs (examples are Garampani in Assam and Badrinath in Uttaranchal). How does this phenomenon occur? Surface water percolates downward through the rocks below the Earth's surface to high-temperature regions surrounding a magma reservoir, either active, or recently solidified but still hot. There the water is heated, becomes less dense, and rises back to the surface through fissures and cracks.

Solid

Ice is the frozen form of water. It occurs when temperatures are below 0 °C (32 °F). For a given mass, ice occupies 9%

more volume than water, which is why when water enters cracks in rocks and freezes it causes the rocks to crack and split. Being less dense than water, ice floats. This property of ice is vital to aquatic life in cold regions. As the temperature drops, ice forms a protective, insulating layer on the surfaces of streams, pools, and other water bodies, allowing water to remain liquid in the layers beneath and life to survive. Glaciers, icebergs, and ice caps are all frozen forms of water.

Gas

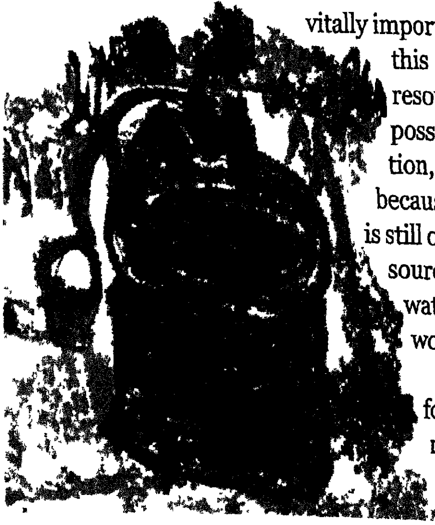
Water is found in the atmosphere in its gaseous form: water vapour. Steam is nothing but vapourized water. In certain hot water springs called geysers, jets of steam and hot water rise one hundred feet or more from the ground. Geysers are found in Iceland, the North Island of New Zealand, and in USA's Yellowstone National Park.

Sources of water

Let us take a more detailed look at the different sources of water on Earth: in some the water is fresh, in others salty.

Groundwater

Much more freshwater lies beneath the ground than is present in lakes and rivers on the Earth's surface. It is hence vitally important to guard this precious natural resource from possible contamination, particularly because groundwater is still one of the main sources of drinking water all over the world.



Groundwater is found in natural rock-formed underground reservoirs and

Artesian wells

Artesian wells have a very long history. In fact, the Persians are credited with having first used this system.

Artesian wells tap the groundwater of aquifers where an overlying, relatively impermeable layer confines water and the pressure is sufficient to raise the water in a well without pumping. This type of spring can have a high water yield. These aquifers have pressure built up within them resulting from a portion of the aquifer being at a higher elevation, which is released when a well is bored into the elevated portion. This causes the well to flow spontaneously.

channels called aquifers. This is the water that we get when we sink a well or bore a pump.

Half the water used by the world for irrigation and in homes comes from this source. It is believed that groundwater is less polluted than surface water; it is, therefore, tapped all the more. In the natural course of things, groundwater is regularly replaced by rainwater that slowly seeps down through the soil into the aquifer.

Let us try to understand how water seeping into the ground gets cleaned. The soil works as a natural filter for the water that enters the ground. If the water is not too impure, it is sufficiently cleaned by filtration through the several layers of soil under the ground. This water can even be drunk quite safely. But today, there is a rise in pollution from agricultural activities, solid waste dumps, acid rain, etc. Once an aquifer is contaminated it is almost impossible to clean it by human means, and it may take years for it to happen naturally. Even where cleaning is possible, the process is very long and costly.

Oceans

The oceans know no boundaries. The water touching the coastline of one country also touches the coastline of another, indirectly uniting us. From ancient times, humans have interacted with the salty waters of oceans. The pleasant climate along most coastlines, as well as the seemingly limitless availability of fish and other marine food sources, encouraged people to settle along seashores. Long before human beings learnt to grow food and settle down in one place, nomadic people were collecting shellfish and harvesting fish. Ancient people like the Egyptians and Polynesians flourished along the coasts and relied on the sea for commerce and transport. Over the centuries, however, cultures around the world began to take the oceans for granted: human activities seemed too small to cause damage to the vast expanses of water. But, the growing demands of an ever-increasing human population led to continuous and ever-increasing exploitation of the ocean's treasures.

Today, we are more dependent than ever before on the oceans—for food, transport, minerals, and even for the manufacture of drinking water. We continue to use the oceans to our advantage, but there is a difference—now, we know much more than before about the marine world.

Salt in the water

Ninety seven per cent of all water on our planet is found in the oceans in the form of saltwater. As water flows through land towards the sea it picks up small amounts of mineral salts from rocks and soil—a process that has gone on for hundreds of millions of years. At the same time, water continuously evaporates from the seas into the atmosphere. However, the salt remains in the water. Therefore, as time passes, the ocean waters get saltier.

Saltwater cannot be used for drinking or irrigation unless it is desalinated, which is a very expensive process. Many countries, particularly in the Middle East, have set up desalination plants to make sea water usable. Each day, Arabian Gulf reverse osmosis plants treat about 500 000 000 gallons of sea water to obtain approximately 100 000 000 gallons of freshwater.

Interesting facts about oceans

- The total length of the world's coastlines is about 504 000 km, enough to circle the Equator 12 times.
- Canada has the longest coastline of any country.
- More than half the world's population lives within a 100-km or 60-mile distance from the coast.
- 80% of all life on Earth is found beneath the ocean's surface.
- The first plants on Earth, the algae, developed in the sea 3.5 billion years ago. Algae, like other plants, give off oxygen as they produce food. Today, algae produce over half of the oxygen that we breathe.
- Antarctica has as much ice as the Atlantic Ocean has water.
- 90% of all volcanic activity on Earth occurs in the oceans. The largest known concentration of active volcanoes (approximately 1133 in number) is located on the sea floor in the South Pacific ocean.

Technology has allowed scientists to study the oceans to greater depths and learn about marine life. We now know that oceans can be harmed by human activity, that pollution of ocean waters not only causes damage to marine life, but threatens people and ecosystems around the world. Today, the oceans are crying out to us for help—to protect them, and thereby all life on Earth, from the damage caused by our own careless activities.

Rivers

All of us have seen a river: large or small, either flowing through our town, or in some other part of the country. This moving mass of water is nothing more than surface water flowing down from a higher altitude to a lower altitude due to the pull of gravity. One river might have its source in a glacier; another in a spring or a lake. Rivers begin as small streams, which grow wider as smaller streams and rivers join them along their course across the land. Eventually they flow into the sea or ocean.

Coral reefs: forests in the ocean

Coral reefs are sometimes referred to as 'tropical rainforests of the deep' since they are among the most diverse, productive, and beautiful marine ecosystems in the world found in tropical waters. The extraordinary diversity of reefs makes them biologically important and, like rainforests, they have provided valuable scientific insights into the nature of underwater ecology. They are also considered to be one of the major sinks for carbon dioxide. A coral reef is made up of a diverse collection of algal species, which interact with one another and with their physical environment. The Sun is the primary source of energy for this ecosystem. Coral reefs are extremely sensitive to any environmental change. When they are environmentally stressed, they lose much of the algae that give them their colour, along with other pigments. When this happens, the corals turn white in colour and are called 'bleached'. Pollutants in the form of sewage, trash, waste from industries, and agricultural run-off can cause immense harm to corals. The Great Barrier Reef is the largest coral reef in the world. It is also one of the most threatened.

Most ancient civilizations grew along the banks of rivers. Because the river was essential to their survival and their main source of livelihood, people worshipped it. Even today, millions of people all over the world live on the banks of rivers and depend on them for their survival.

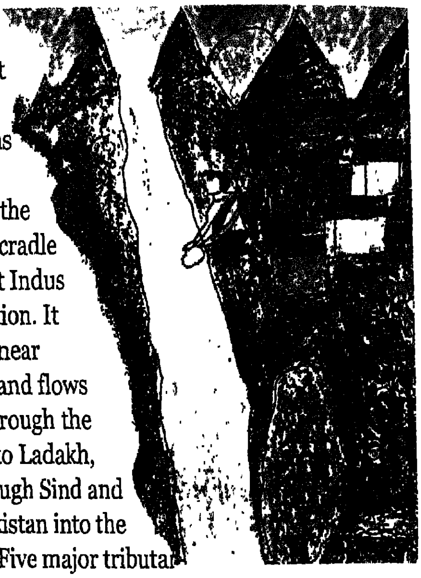
India has a large number of rivers that are lifelines for the millions living along their banks. These rivers can be categorized into four groups.

- Rivers that flow down from the Himalayas and are supplied by melting snow and glaciers; this is why these are perennial, that is, they never dry up during the year
- The Deccan Plateau rivers, which depend on rainfall for their water
- The coastal rivers, especially those on the west coast, which are short and do not retain water throughout the year
- The rivers in the inland drainage basin in west Rajasthan, which depend on the rains; these rivers normally drain towards the lakes or flow into the sand.

The major rivers in India are described below.

Ganga This is considered the holiest of all the great rivers of India. It has its source at the Gangotri glacier, where it flows from the cave Goumukh as the Bhagirathi and then joins the River Alaknanda as it flows towards Devaprayag. The largest tributary of the river is the Ghaghara, which flows from the northern Nepal region and joins it before Patna in Bihar. Another major tributary is the Yamuna originating in the Yamunotri glacier, that flows through Delhi and Agra and joins the Ganga at Allahabad. Others are the Gomti, Gandak, Son, Kosi, Chambal, Sarda, etc. The Ganga is the lifeline for more than millions of people living along its banks.

Brahmaputra This mighty river rises in western Tibet in the Manasarovar region. It flows eastwards through the Himalayas, curves back across Arunachal Pradesh and Assam, and then turns south to join the Padma and Ganga in Bangladesh and enters the Bay of Bengal. It is known by several names as it flows through Tibet, China, and the northeastern states of Arunachal Pradesh and Assam. It is longer and more voluminous than the Ganga, and gushes down with enormous force for most of its course through the mountain regions and the forests of north-east India. A unique feature of this river is that



it is navigable even at a height of 10 000 feet.

Indus Known as the Sindhu in ancient times, the Indus was the cradle of India's great Indus Valley civilization. It has its source near Manasarovar and flows westwards, through the Himalayas into Ladakh, and then through Sind and Punjab in Pakistan into the Arabian Sea. Five major tributaries from India, the Jhelum, Chenab, Ravi, Beas, and the Sutlej join the river.

Narmada Narmada is the largest westward-flowing river in India and originates from the Mekhala ranges in Shahdol district, Madhya Pradesh. It flows through the states of Madhya Pradesh and Gujarat before draining

Interesting legends

- Puruva, a ruler in ancient India, is said to have brought the Narmada down to Earth after doing penance to please Lord Shiva
- Yamuna is better known in legend as the queen consort of Lord Krishna
- Gomti is said to be the daughter of the sage Vashishtha and the supreme liberator of all sins
- According to the Puranas, the Ganga is the holiest of all shrines on the Earth

into the Arabian Sea. It is said to be one of the most beautiful rivers in India.

Mahanadi The Mahanadi river is considered the lifeline of Orissa, through which it flows. It has its origin in southeastern Madhya Pradesh near Raipur, with 53% of its catchment area in this state.

Godavari The Godavari originates in the Sahyadri range of Maharashtra. It flows through that state and Andhra Pradesh before entering the Bay of Bengal. Its drainage basin is one of the largest in the country.

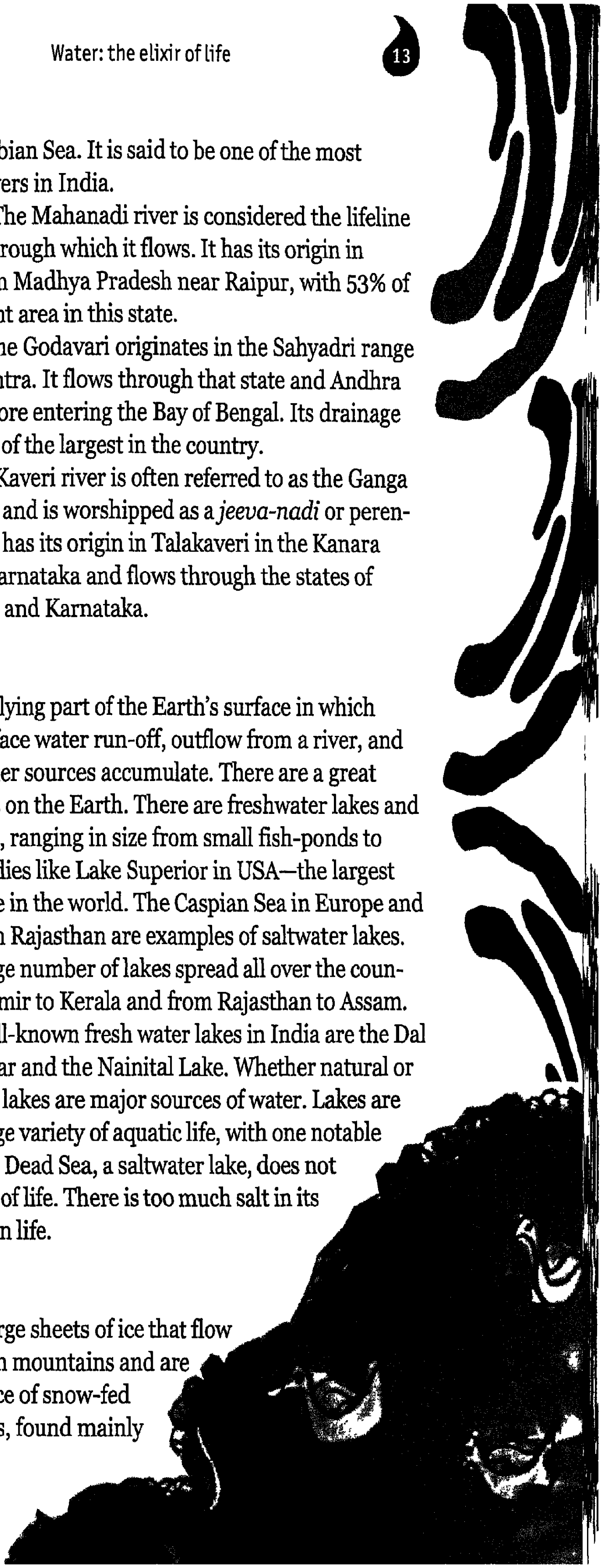
Kaveri The Kaveri river is often referred to as the Ganga of the south and is worshipped as a *jeeva-nadi* or perennial river. It has its origin in Talakaveri in the Kanara district of Karnataka and flows through the states of Tamil Nadu and Karnataka.

Lakes

A lake is a low-lying part of the Earth's surface in which rainwater, surface water run-off, outflow from a river, and water from other sources accumulate. There are a great variety of lakes on the Earth. There are freshwater lakes and saltwater lakes, ranging in size from small fish-ponds to huge water bodies like Lake Superior in USA—the largest freshwater lake in the world. The Caspian Sea in Europe and the Sambhar in Rajasthan are examples of saltwater lakes. India has a large number of lakes spread all over the country, from Kashmir to Kerala and from Rajasthan to Assam. Among the well-known fresh water lakes in India are the Dal Lake in Srinagar and the Nainital Lake. Whether natural or man-made, all lakes are major sources of water. Lakes are homes to a large variety of aquatic life, with one notable exception: the Dead Sea, a saltwater lake, does not have any form of life. There is too much salt in its water to sustain life.

Glaciers

Glaciers are large sheets of ice that flow down very high mountains and are often the source of snow-fed rivers. Glaciers, found mainly



in places like Antarctica and Greenland, cover almost 10% of the Earth's landmass. They vary in size.

A glacier begins life as snowflakes. As more and more snow falls and gathers, the weight of the snow on top compresses the lower layers to form ice. The pile of snow and ice becomes thicker and heavier till the point when the layer of ice at the very bottom melts under the pressure. It re-freezes almost at once; but the process is repeated over and over, and as a result the entire mass begins to slide downhill slowly along the rock surface. A glacier has an enormous impact on the topography of the area as it moves, pushing aside boulders, cutting through rocks, and denting its path.

In India, glaciers are found in the Himalayas. Beneath the serenity and awesome size of these mountains, there is great activity! The Himalayas are a young mountain range. They were formed when the Indian subcontinent collided with the mainland of Asia about 40 million years ago. There are about 15 000 glaciers flowing through these mountains, covering about 17% of the mountain area and supporting numerous perennial rivers such as the Ganga, Indus, and Brahmaputra. Some well-known glaciers are described below.

Dokriyani The Dokriyani glacier is believed to be as old as the Himalayan mountains. It originates at an altitude of 13 000 feet in Uttaranchal's Garhwal. It is one of the most studied glaciers in the world. A recent study says that it has been shrinking by a few metres every year.

Gangotri Gangotri is located in Uttaranchal's Tehri Garhwal. One of the oldest glaciers in this range, it is where the river Ganga originates.

Pindari Pindari is one of the most beautiful glaciers in the Kumaon hills. Known as the Jewel of Kumaon, it is located at a height of 13 000 feet above sea level.

Bara Shigri The largest glacier in Ladakh, Bara Shigri is in Lahaul subdivision. It flows into the river Chandra and its name signifies 'boulder-covered ice'.

Gangstang Gangstang glacier is on the western border of the Lahaul region at an altitude of about 17 970 feet and streams into the Shahsha Nullah.

Sonapani The Sonapani glacier is visible from the Rohtang Pass, and is about 11 kilometres long.

The 'small and big' of water

- The deepest lake is Lake Baikal in Siberia, Russia. The deepest point of the lake is known as the Olkhon Crevice; it has a depth of 5370 feet.
- The largest saline lake is the Caspian Sea, spread over Iran, Russia, Turkmenistan, Azerbaijan, and Kazakhstan with a surface area of 1 43 560 square miles and an estimated volume of 21 500 cubic miles.
- The most threatened lake in terms of size is the Aral Sea, which has shrunk due to extraction of water for irrigation.
- The Pacific Ocean is the biggest and covers approximately 32.6% of the Earth's surface.
- The Arctic Ocean is the smallest ocean.

Zemu The Zemu glacier is the largest and most famous glacier in the eastern Himalayas, about 26 km long. It is located in northwestern Sikkim in a U-shaped valley at the base of the Kanchenjunga massif. The Teesta river has its source in this glacier.

Siachen Siachen is the largest glacier in the world outside the Polar regions, stretching over a length of about 72 km. It lies in the extreme north-central part of Jammu and Kashmir near the border of India and Tibet, on the north-facing slopes of the Karakoram Range, and feeds the Shaksgam river that flows into Tibet. The glacier can be approached from Skardu in Ladakh. To the east of the Siachen lies a group of three glaciers known as the North, South, and Central Rimo. In total, these glaciers have almost 700 square kilometre of ice.

Wetlands

Wetlands are areas covered by water that support flora and fauna specially adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, mangroves, and similar areas. These wetlands are very important to our environment as they recharge the groundwater table, maintain soil moisture, control floods, maintain the flora–fauna relationship, and preserve biodiversity.

Natural wetlands

Natural wetlands are found everywhere—from the tundra to the tropics, and on every continent except Antarctica. They vary because of regional and local differences in soil, topography, climate, hydrology, vegetation, and other factors. Natural wetlands can be put into two general categories: coastal or tidal and inland.

Coastal wetlands

In such wetlands, sea water mixes with freshwater. The saltwater and the fluctuating water levels combine to create a rather difficult environment for most plants; only some adapt successfully. Mangrove swamps, with salt-loving shrubs and trees, are common wetlands in tropical climates such as in the Sundarbans.

Inland wetlands

These are most common on flood plains along rivers and streams (riparian wetlands) and in other low-lying areas where the groundwater levels are high or where rainfall is very heavy and the soil gets saturated very fast. Inland wetlands include marshes and swamps.

India has designated six Ramsar Wetland sites: Keoladeo National Park, Chilika Lake, Loktak Lake, Wular Lake, Sambhar Lake, and Harike Lake. These wetlands broadly represent Himalayan freshwater wetlands, coastal lagoons, flood plain systems, and arid zone wetlands.

The Ramsar Wetland Indian sites

Keoladeo National Park also known as the Bharatpur bird sanctuary, in Rajasthan, is an important habitat for waterfowl. It is the only wintering site in India for the central and western Asian population of the highly endangered species, the Siberian crane. The population of these birds has decreased in the last two decades, owing to increasing human activities and the degradation of its habitat. Reared Siberian crane chicks brought from the USA and Siberia have been introduced to ensure a steady population.

Chilika Lake in Orissa, India's largest brackish water lagoon, was designated a Ramsar Wetland of International Importance, in 1981. It is one of the hotspots of biodiversity and is home to a number of endangered species listed in the IUCN (The World Conservation Union) red list of threatened species. It provides refuge to thousands of migratory birds and the balance in the ecosystem has to be maintained to ensure safe habitat for the birds. But, its fragile ecosystem has, of late, come under threat due to both human activities and natural factors.

Loktak Lake in Manipur, is the largest natural wetland in north-east India. The catchment area is about 98 000 hactare. Thick floating patches of weeds covered with soil, called 'phumdis', are a characteristic features of this lake. Keibul Lamjao National Park, home to the threatened brow-antlered deer, is located in the area south-east of the lake. Several measures have been adopted to control the prolific growth of *phumdis* and water hyacinth. Weevils have been introduced for biological control of the water hyacinth.

Harike Lake, formed by damming the Beas – Sutlej watershed, is the largest wetland system in Punjab. The lake attracts a large number of migratory birds. Because of heavy siltation due to denudation in the catchment area, the ponded area is gradually decreasing. Afforestation of catchment area has been carried out in some critical areas to control siltation. One of the major problems of the wetland is the prolific growth of water hyacinth.

Wular Lake in Kashmir is the source of drinking water for Srinagar, and acts as an absorption basin for floodwater. It is an important waterfowl habitat. The wetland, however, is subjected to heavy siltation due to loss of vegetal cover of the area.

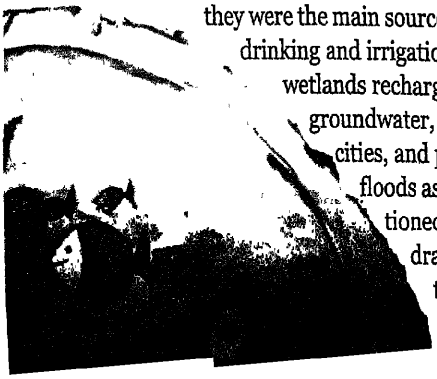
Sambhar Lake, located in the arid zone of Rajasthan, is one of the largest inland saline lakes in India. This wetland is one of the most important wintering areas for flamingoes in addition to a large number of Pelicans. Salt extraction is one of the major activities of the wetland.

Some interesting snippets on water

- 75% of the Earth's surface is covered with water.
- About 2% of the available drinking water is frozen and only 1% remains for drinking purposes.
- The world's average rainfall is about 850 mm.
- Water regulates the Earth's temperature. It also regulates the temperature of the human body, carries nutrients and oxygen to cells, cushions joints, protects organs and tissues, and removes waste.
- 60%–75% of the adult human body is water: 82% of blood; 70% of the brain, and 90% of the lungs.
- Blood in animals and sap in plants is composed mainly of water.
- More than half the creatures on the Earth are found under water.
- Life on earth probably originated in water.
- The dominant constituent of some vegetable is water: 95% in tomato, 91% in spinach, 91% in milk, 85% in apples, and 80% in potatoes (approximate).
- Water expands by 9% when it freezes. Frozen water (ice) is lighter than water, which is why ice floats in water.
- 10% of the Earth's surface is covered with ice.

Urban wetlands

Urban wetlands are found all over the country, and are either natural or built by people. Through the ages, urban wetlands have been the lifeline of most cities in the world. They were preserved and looked after by the people, as they were the main source of water for drinking and irrigation. These wetlands recharged the groundwater, cooled the cities, and prevented floods as they functioned as natural drainage systems. During ancient and



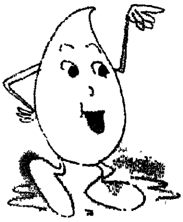
medieval periods, tanks were constructed in the catchment areas of cities that were not located near a river or a large lake. Rainwater or run-off would collect during the rainy season and be stored in these tanks and lakes, supplying the city with water. In southern India, the towns were built around temples, each of which always had a tank at the centre. Wells were located in the tank, which served as links with the aquifers.

Unfortunately, over the years these tanks and wetlands have been neglected or encroached upon, either to accommodate more houses or to dump waste. This has caused large-scale water crises, monsoon flooding, and waterlogging, leading to misery and disease. Urban wetlands that have been protected for centuries are now being ravaged and destroyed in the name of development.

Town planners and architects have noted that wetlands are very effective in removing waste from water. Now wetlands are being constructed by forward-thinking, environmentally-sensitive city planners for this purpose. Artificial wetlands are used as additional water-treatment systems by directing storm water and previously treated sewage effluent into them.

Gathering the yarn

We have taken a quick look at the places on Earth where we can find water, as it ceaselessly moves between the solid, liquid, and gaseous states; between lands, oceans, the atmosphere, and underground aquifers; between life and non-life. Already we have an idea of how essential water is to life on Earth, including human life, and of the intricate links between different parts of the great, complex equilibrium called the hydrological cycle. In the next chapter, we will see how disturbances in any part of this cycle have far-reaching consequences.



Pollution, contamination, and depletion

There is an orderliness in the universe, . . . there is an unalterable law governing everything and every being that exists or lives.

Mahatma Gandhi

What we have done to the water around us

The blue river, lake, or stream that each child has in mind when colouring a water body is something we do not see any more when we look around us. Rivers look like they have been churned with a lot of brown and black and have a colour that is no longer soothing to the eye. This is what we have done to our water bodies over the years—dirtied them and almost destroyed them. They are, today, not only highly polluted and contaminated, but are also depleting due to our consumption pattern.

The world is heading towards a freshwater crisis due mainly to the mismanagement of our resources and environmental degradation, which has lead to lack of access to safe water by millions of people. This crisis is already evident in many parts of the world, varying in scale and intensity depending on the time of the year, climate, and location.

As water passes through the hydrological cycle, both natural processes and human activity affect it. In nature, water can contain impurities. For instance, water that infiltrates into the ground passes through several layers of soil and rock under the ground. Depending on the soil and rock conditions, this water dissolves or absorbs substances such as ammonia, sodium, hydrogen sulphide, oxygen, metal and chemical impurities, and suspended impurities such as microscopic plants and animals. This is why, in some areas, even arsenic and fluoride, harmful to health beyond a certain concentration, are found naturally in the groundwater. It also contains dissolved and suspended impurities from the atmosphere.

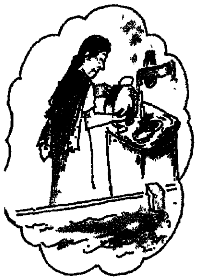
More hazardous water pollution is caused by human activities such as agriculture, urbanization, and industrialization. With more and more people, industries and cities, the quantity of waste produced has also increased.

In coastal areas over-exploitation of groundwater resources is leading to sea (saline) water intrusion into the groundwater. This primarily happens because groundwater tables on the land go below the mean sea level.

Pollutants in the water

Chemicals in water can occur naturally or be introduced by human interference and can seriously affect health.

Chemicals in drinking water



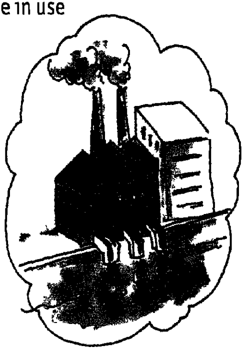
Fluoride in the water is essential for protection against dental caries and weakening of the bones; but at higher levels it can have an adverse effect on health. In India, water with a high fluoride content is found naturally in parts of Rajasthan, Uttar Pradesh, Bihar, Jharkhand, and a few other states.

Arsenic occurs naturally in the ground. High concentrations of arsenic in water can have an adverse effect on health. A few years back, it was found in high concentrations in drinking water in six districts of West Bengal.

Lead is present in pipes, fittings, and solder in household plumbing systems that contaminates the drinking water source.

Pesticides in run-off from agricultural fields contaminate the water.

Nutrients in water bodies caused by the presence of phosphorus and nitrogen in domestic waste water, agricultural run-off, manure from livestock, and industrial effluents can cause eutrophication in the lakes and rivers, which can spread to coastal areas.



Synthetic organics are found in the aquatic environment, as thousands of synthetic compounds are in use today, and accumulate in the food chain. POPs (persistent organic pollutants) represent the most harmful elements to the ecosystem and for human health; for example, industrial chemicals and agricultural pesticides.

Acidification of water in lakes and reservoirs are caused by sulphur dioxide from power plants, heavy industries such as steel plants, and from motor vehicles. This environmental problem is severe in the US and in parts of Europe.

Petrochemicals contaminate the groundwater when they leak out of underground petroleum storage tanks or are released during oil spills.

Other heavy metals as contaminants come from mining, landfills, or hazardous-waste dumps.

Eutrophication

Eutrophication occurs when nutrients flow into water causing abnormal plant growth. This can be due to run-off of chemical fertilizers from fields, domestic sewage, industries, etc. Water contains micro-organisms that break down organic waste into harmless substances by utilizing oxygen dissolved in water. Sometimes there is too much organic matter and the natural micro-organisms are unable to break down all of it. The excess of organic matter or nutrient encourages rapid growth, or blooms, of opportunistic species such as algae and weeds. When they die their remains add further to the organic waste already in the water. Eventually, all the oxygen is used up. Anaerobic organisms (those that do not require oxygen to live) then attack the organic waste, releasing gases such as methane and hydrogen sulphide, which are harmful to the aerobic (those that require oxygen to live) forms of life. The result is a foul-smelling, waste-filled body of water, a situation that has occurred in Lake Erie and the Baltic Sea and threatens freshwater lakes all over the world. Eutrophication has changed the ecology of several lakes. In India, a good example is the Dal lake in Srinagar, Kashmir.

Microbial pollution is caused by infective agents (pathogens) in water such as viruses, bacteria, worms, etc. Faecal waste in untreated sewage in urban areas, and in the open in both urban and rural areas, is one of the main sources of microbial contamination. Water-borne diseases are found in areas with poor sanitary conditions.

Surface water

Urban sewage, agricultural run-off, and industrial effluent are some of the main sources of water pollution.

Sewage

Untreated or inadequately treated municipal sewage is a major source of groundwater and surface water pollution in

Biochemical oxygen demand

The most important test of waste water is the one that determines the BOD (biochemical oxygen demand) by measuring the organic matter in sewage that can be biologically stabilized (by micro-organisms that feed on the organic matter). The more organic material there is in the sewage, the higher the BOD. Industrial effluent may have BOD levels many times that of domestic sewage. When sewage enters a lake or stream, decomposition of its organic components begins. Oxygen is consumed as micro-organisms use it in their metabolism. This can quickly deplete the available oxygen in the water. When the level of dissolved oxygen drop too low, fish and other life forms perish. If there is no oxygen, the water will turn septic.

developing countries. This is generated in our homes and offices and comprises used water from toilets, bathrooms, kitchen, and other household activities. It contains a wide variety of dissolved and suspended impurities, mainly organic material, and plant nutrients such as phosphates, from synthetic detergents

The organic material in municipal waste that is discharged into rivers uses up a lot of the river's dissolved oxygen for biological degradation. This upsets the ecological balance of these water bodies. Sewage also carries microbial pathogens that spread disease.

In urban areas, water is contaminated by

- garbage dumped into rivers,
- direct inflow of untreated sewage,
- untreated effluents from industries ,
- leaching of pollutants into groundwater sources, and
- leaks in sewage lines in areas where water and sewage pipeline are close to each other.

The large volumes of sewage produced in urban areas make its treatment and handling very difficult.

Agriculture

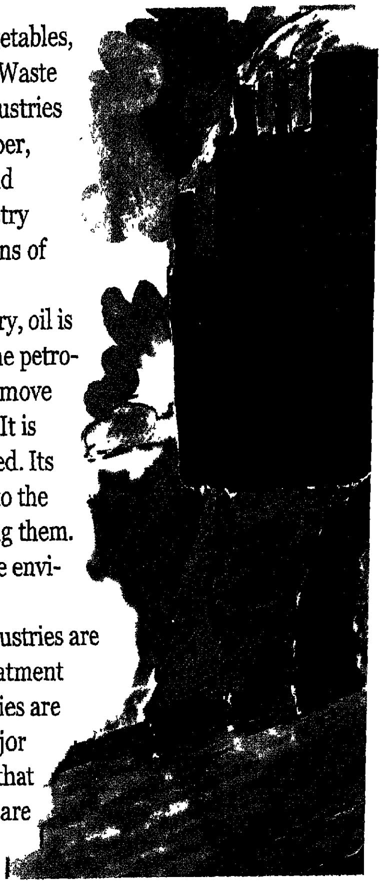
This sector is the single largest user of freshwater, consuming about 70% of it. The way farmers plant and water their crops influences the quality of groundwater and surface water sources greatly. Intensive cultivation of crops, using chemical fertilizers (nitrates and phosphates) and pesticides, contaminates water bodies. The incidence of high nitrate concentration in groundwater has been mainly due to leaching of irrigation water into the groundwater from agricultural fields that have been sprayed with chemical fertilizers along with leaching from animal manure used in the fields that also contains bacteria and organic matter. Poor farming practices can cause soil erosion, and inefficient methods of irrigation can lead to water-logging and salination. This has been seen, following the Green Revolution in Punjab, Haryana, Uttar Pradesh, and Tamil Nadu, and other parts of the country. One of the best examples of things going wrong can be seen in the Aral Sea basin in Central Asia, where farming practices that were not environment-friendly contaminated the water. This has affected the health of thousands of people in the area.

Water pollution due to agriculture is more common in the developed countries because of the extensive use of chemical fertilizers and pesticides. As our population is increasing, the need to improve production and produce more food is very important. The challenge now is to ensure that farming methods do not adversely affect water quality and thereby the quality of life.

Industrial effluents

Rapid industrialization has increased the level of pollutants in water sources. Industrial processes and waste disposal practices have contaminated freshwater supplies. Industries that use a lot of water, such as chemical, steel, and textile plants, discharge their waste into streams and rivers. Run-off and seepage from waste is stored in deep wells, which also pollute water sources.

Industrial waste may contain organic and inorganic substances. Organic waste includes agro-based residues, pesticide residues, solvents, cleaning fluids, dissolved



residue from fruits and vegetables, and pulp and paper waste. Waste water from agro-based industries such as sugar, pulp and paper, distilleries, and the fruit and vegetable processing industry contains high concentrations of dissolved organic matter.

In the petroleum industry, oil is mixed with water during the petroleum refining process to remove salts and other impurities. It is then separated and collected. Its residue is released back into the water bodies contaminating them. Spills and leaks damage the environment extensively.

Though most major industries are equipped with effluent treatment plants, small-scale industries are not, which constitute a major source of pollution. Wells that are thousands of feet deep are used by the chemical industry to store and dispose of waste. Highly toxic waste injected into aquifers or leakage of contaminant from wells and tubes cause groundwater contamination. Smaller units like drycleaners use solvents and hazardous chemicals to clean the clothes.

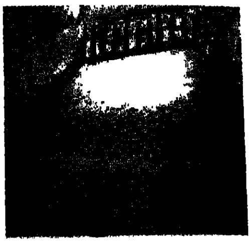
A large number of industries now recycle their waste water.

Groundwater

Until a few years back groundwater was considered safe and dependable. The story has changed now. Due to ever increasing demand in urban areas, and in the agricultural and industrial sectors, freshwater has become the most precious

The Dal Lake

The Dal Lake is situated at an altitude of 1580 metres above sea level east of Srinagar in the Zaberwan mountains. In the last decade or so, the lake has shrunk from 58 square kilometres to the present 11.05 square kilometres. Continued agricultural activity in the floating gardens and catchment areas, land reclamation, encroachments, and constructions in and around the lake have all contributed to its steady degradation. On the surface, the lake still looks beautiful, but it has been polluted with sewage and poisonous effluent. The once crystal clear water of the lake is now red with algae, believed to be the first sign of drying up. It has turned the water toxic and it is no longer safe even for fish breeding, say experts. Alarmed by the steady environmental decline of the lake, the Jammu and Kashmir Government set up the Lakes and Waterways Development Authority in 1997 for restoring the lost glory of the lake.



natural resource. This water is not only contaminated, it is also depleting fast. Water extraction without proper recharge and leaching of pollutants from effluents, wastes, and agricultural run off into the aquifers have polluted groundwater sources. It is susceptible to contamination from pesticides and nitrates mobile in the soil. It is a matter of concern, as these chemicals persist in soil and water.

Discharge of untreated waste water through bores and leachate from unscientific disposal of solid waste contaminates groundwater,

Toxic waste

Toxic waste is the most harmful form of pollution to marine creatures and humans alike. Once a form of toxic waste affects an organism, it can be quickly passed along the food chain and might eventually end up in seafood, causing various problems. Toxic waste enters the water through leakage from landfills, dumps, mines, and farms. Studies have shown presence of pesticides in fish.

Radioactive wastes, reactor leaks, natural radioactivity, and radioactive particles from testing explosions of nuclear weapons, are found in water all over the world. Radioactive substances are produced in the form of waste from nuclear power plants, and from the industrial, medical, and scientific use of radioactive materials.

making urban run-off a major contributor. Studies show that leachate and run-off from cities carry iron, lead, copper, other heavy metals and toxins, industrial chemicals, nutrients, petroleum-based hydrocarbons, nitrogen, and phosphorus. Seepage from unlined surface dump ponds can contaminate groundwater.

Air pollution affects and contaminates groundwater. When the air is polluted, rainfall will settle many pollutants on the ground, which can then seep into and contaminate groundwater sources.

Groundwater is also contaminated by naturally occurring minerals such as fluoride, arsenic, mercury, and iron. In many areas, water is saline; this may be due to natural causes and also due to extensive use of chemicals in agricultural activities. Arsenic may be found in water, which has flowed through arsenic-rich rocks. Some fluoride compounds in the Earth's upper crust are soluble in water and are, therefore, found in both surface water and groundwater.

Marine pollution

Oceans cover over 70% of the surface of the Earth. Most rivers and streams flow into them. All impure materials that

Oil spills

More than 60 million gallons of oil enter the oceans every year, but this is not reported. This is because most of this oil seeps from oil-bearing rock layers into the ocean as part of a natural process.

Spills occurring from damaged or leaking oil tankers are common. The Exxon Valdez oil spill off the coast of Alaska is an example of the damage that can be caused by an oil spill. The most recent disaster has been the Prestige oil spill off the coast of Spain. These large-scale accidental discharges of petroleum are an important cause of pollution along shore lines. Oil pollution is a growing problem, particularly devastating to coastal wildlife. Small quantities of oil spread rapidly across long distances to form deadly oil slicks.

find its way to the world's seas is classified as 'marine pollution'. Waste water from towns and cities, effluent from industries, and run-off from agricultural fields flow through streams and rivers into the oceans. Oil spills in the seas and dumping of toxic and other types of waste add to pollution in the ocean. Currents move pollutants far from their sources, spreading them rapidly all over the world.

Marine pollution directly affects marine life and indirectly affects human health and resources. Large populations live along the coastline and depend on the seas for their livelihood. When an oil spill occurs along a coastline, it affects human population as well as wildlife.

Depletion

The demand for water has increased over the years, leading to its scarcity in many parts of the world. Water depletion has become a major problem with falling groundwater tables, drying rivers, and silting lakes. Cities, agricultural fields, and industries all compete for this scarce resource. Meanwhile, populations continue to grow fast in some of the world's most water-scarce regions to numbers larger

'A wet desert'

Cherrapunji in Meghalaya, India, receives very heavy rainfall and is considered to be one of the wettest places on Earth, yet suffers from acute water shortage. During certain months, people walk miles for drinking water. Robin Clarke in his book *Water: the International Crisis* has rightly described this area as the 'wettest desert in the world'. This shortage of water has been attributed to erosion due to large-scale deforestation in this hilly region and mismanagement of existing resources.

than can be sustained by the existing water resources. According to the United Nations Environment Programme, Asia and the Pacific region account for about 36% of the global run-off, but have the lowest per capita availability of freshwater.

Depletion in your household

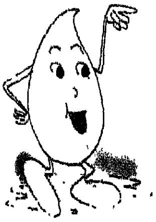
- A dripping tap can waste as much as 60 litres per day or 1800 litres per month.
- A leaking toilet can waste up to 100 000 litres of water per year.
- It takes about 2.5 litres of water to cook pasta and about 5 litres to clean the pot.
- The average bath tub holds between 150 and 200 litres of water when filled to the brim.
- To cook 1 cup of rice you need 2 cups of water, but to wash the pan in which it has been cooked, requires about 4–5 litres of water

During the past two decades, the groundwater table has fallen rapidly in several parts of the world due to an increase in extraction. Uncontrolled use of modern technology has led to the extraction of groundwater to such an extent that often recharge is not sufficient. Excessive tapping of groundwater, through numerous bore wells and deep tube wells, has led to a decline in the water table, whose means of replenishing itself have been greatly hampered.

This is being done to irrigate fields and cater to the rapidly rising population and changing lifestyles. The water requirement for the industry also shows an overall increase. All the sectors – agriculture, industry, and domestic – seem to be literally in competition, driving the groundwater table lower.

These, coupled with growing needs, have led to increasing dependency on groundwater.

Groundwater depletion has acquired a serious dimension in most parts of India. Salinity ingression due to over exploitation of groundwater resources is threatening to wipe out many agriculture-based coastal economies. Many areas are afflicted by the problem of excessive water-logging due to poorly managed canal systems.



Health impact of water pollution

We let a river shower its banks with a spirit that invades the people living there, and we protect that river, knowing that without its blessings the people have no source of soul.

Thomas Moore

How water pollution has affected us

Freshwater resources all over the world are threatened not only by over-exploitation and poor management, but also by ecological degradation and environmental pollution, as we have read in the previous chapter.

It is a well-known fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean drinking water is a basic need for all human beings, yet it has been observed that millions of people worldwide are deprived of this.

Drinking water in the true sense can be termed as safe good quality water that is free from disease-carrying micro-organisms and chemical substances that are harmful for human health.

Many water sources have been contaminated or submerged, leaving no access to clean drinking water. Each year, communities throughout the world face water quality problems when micro-organisms make their way into

public and private water supplies at levels that can cause disease. Often, flooding of wells and septic systems mix drinking water with contaminated water and cause a breakage in water supply. People marooned in flooded areas are susceptible to diseases such as cholera, malaria, dengue fever, and dysentery. During droughts, scarcity of water causes greater contamination of water sources, and there is consequently an increase in water-borne diseases.

In urban areas, water gets contaminated in many different ways leading to water-borne diseases that are highly infectious. In order to prevent the spread of these diseases people should take precautions.

Hazards of polluted water

These may be grouped into two, biological and chemical.

Biological hazards

Biological hazards are caused by the presence of infective agents in the water such as viruses, bacteria, worms, etc. Since water is mainly responsible for the diseases they cause, these diseases are termed water-borne diseases. All these diseases are infectious and are spread directly or by insects such as flies. Faecal waste is one of the main sources of transmission of infectious intestinal diseases. These diseases are more prevalent in areas with poor sanitary conditions. Pathogens – which include viruses, bacteria, protozoa, and parasitic worms – are disease-producing agents found in the faeces of infected persons. Disease-causing protozoa can sometimes be found in water in rural or developing areas. The faeces of wild animals containing protozoa can also contaminate water supply.

Pathogens travel through water sources and enter the bodies of persons handling food and water. Since these diseases are highly infectious, people looking after an infected patients should maintain extreme care and hygiene. Hepatitis, cholera, dysentery, and typhoid are

the more common water-borne diseases that affect large populations in the tropics. In drinking water, microbes such as bacteria and viruses, have the greatest chance of reaching levels high enough to affect health seriously. Most people's bodies can fight off these microbial contaminants the way they fight off germs, and these acute contaminants typically don't have permanent effects. However, high levels of these microbes can make people ill.

Chronic effects occur when people drink water containing contaminants at levels over safety standards, and over a period of time. Such effects of contaminants are cancer, liver or kidney problems, or reproductive difficulties. Water-borne and water-related diseases such as diarrhoea, typhoid, cholera, and infectious hepatitis account for 80% of India's health problems.

Coliforms aren't necessarily hazardous, but they indicate the presence of other hazardous micro-organisms in water. These micro-organisms can cause enteric diseases by infecting the cells of the intestinal lining, either growing on them or in them. The resulting diseases can be serious, and occasionally fatal. Symptoms can include cramps, diarrhoea, vomiting, nausea, and sometimes fever.

Chemical hazards

A large number of chemicals that exist naturally on land or are added by human activity dissolve in the water, thereby contaminating it and turning it into a potential source of disease. The chemical content from detergents, solvents, dyes, ammonia, heavy metals, mineral and organic acids, nitrogenous substances, bleaching agents, sulphides, and toxic organic compounds of great variety can affect our health, both directly and indirectly, by accumulating in aquatic life such as fish and also in animals and plants that are consumed by humans.

Pesticides The organophosphates and carbonates present in pesticides damage our

Criteria for good drinking water quality

- Colourless, odourless, and tasteless
- Free of chemical substances such as chlorides, ammonia, nitrites and nitrates, arsenic, cadmium, cyanide, lead, mercury, fluoride, and selenium
- Should not have hardness or be saline
- Free of bacteria such as *E. coli*, and faecal streptococcus, which indicate faecal pollution

- Local bodies need to set up sewage treatment plants.
- Solid waste such as plastic bags, containers, and paper should not be thrown in sewage drains.
- Water storage tanks must be cleaned regularly.
- Proper bore well development and sanitary water storage and transport systems is the key to safety.

In urban areas, local bodies are responsible for treating and supplying water. PHCs (primary health centres) were set up in rural areas in India from 1952 onwards, and sanitation and drinking water programmes were included in the Fifth Five Year Plan.

The main constraints with regard to water supply are inadequate maintenance, lack of finances, and poor community involvement. Most municipalities do not have any system for monitoring the quality of water to detect and eliminate contamination that causes water-borne diseases. Most people in rural areas are not aware of the health and environmental benefits of improved sanitation.

Maintaining the quality of household tap water

The most common method used to determine if water supplies are contaminated is a coliform test. Coliforms are bacteria that live in the intestines of humans and animals. Coliforms in water samples are easy to identify under a

What is reverse osmosis?

Reverse osmosis is a method of filtration by which the water is first mechanically filtered with a sediment filter and then pressed through a semi-osmotic membrane. The membrane separates water from the rest of the total dissolved solids (impurities). Then the water is passed through a carbon block filter to remove taste and odour. A reverse osmosis system has a holding tank for the purified water. It is used to remove salt from sea water.

microscope when specially stained. High concentrations would mean contamination by faeces.

Here are some methods that can be used at homes to make water safe for drinking.

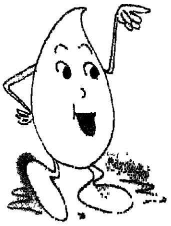
Filtration is one way to remove some contaminants from water, and several water filtration systems are available for home-use. But, no filter system is completely effective. Physical filters are made of fibres, ceramics, or fabric. Activated carbon filters often include silver, an element toxic to some micro-organisms.

Reverse osmosis is an effective method as it eliminates all impurities from the water.

Ultraviolet disinfection units pass water through a beam of ultraviolet light. Ozone, a naturally occurring form of combined oxygen molecules that destroys certain micro-organisms has been used to treat water, but it is expensive. Sometimes, different systems are combined to treat water in small quantities.

Even today, with many advances in technology, the best way of killing micro-organisms in water is to boil it for 20 minutes.

At the municipality and industry levels, water can be rendered safe for passing into the sewer, inland water source, seas, rivers, or utilized for agriculture and irrigation by using a combination of methods.



Conservation of water

> *Anything else you're interested in is not going to happen if you can't breathe the air and drink the water. Don't sit this one out. Do something. You are by accident of fate alive at an absolutely critical moment in the history of our planet.*
>
> *Carl Sagan*

Imagine a day without water; no water to drink, to wash, for cooking; just no water around you! At the rate we are going, this could be the scenario in the next century or so unless we take some drastic steps. Already, in many parts of the world, water is so scarce that people have to walk miles to fetch a bucket of freshwater.

Conservation of water today aims at bringing a balance between demand and supply. What is needed is efficient management of water to ensure a steady supply for the future. The way to this is by a good conservation policy and sensitized citizens. This is required to raise the water table and also to improve the quality of surface water in rivers,

Nature's system

Rainwater falling in the forests seeps gently into the ground as the vegetation breaks the fall. This groundwater in turn feeds the wells, lakes, and rivers. Protecting forests results in protecting water 'catchments'. In ancient India, people believed that forests were the 'mothers' of rivers and worshipped the sources of these water bodies.

streams, and lakes; arrest sea water moving further inland, and conserve surface water run-off.

The United Nations and other organizations are encouraging the revitalization of traditional water harvesting and supply technologies in arid areas because they feel it is an important method of sustainable water utilization.

In ancient times, water was acknowledged and regarded as a valuable and essential resource. Rainwater was a precious gift of Nature, water was worshipped, and there were various festivals that centred round water and rain. All ancient cultures flourished near water resources. Civilizations all over the world used various methods of conserving water—tanks, reservoirs, check dams, cisterns, and roof-top harvesting were some of them.

Varahamihira, the Indian mathematician who lived in the 5th century AD, has left a detailed account of water systems in India during the period. Construction methods and materials used for dams, tanks, bank protection, etc. mentioned in ancient books reflect the advanced stage of development of water resources and hydrology in ancient ndia.

Some methods followed in different parts of the world in bygone days are described below.

- The Indus Valley civilization, that grew along the banks of the river Indus and other parts of western and northern India about 5000 years ago, had one of the most sophisticated urban water supply and sewage systems in the world. The fact that the people were well acquainted with hygiene can be seen from the covered drains running beneath the streets of the ruins at both Mohenjodaro and Harappa. Another very good example is the well-planned city of Dholavira, on Khadir Bet, a low plateau in the Rann in Gujarat. Archaeologists have uncovered an extensive and remarkably sophisticated water supply system that included finely chiselled reservoirs, wells, and rainwater tanks.
- One of the oldest water harvesting systems is found about 130 km from Pune along Naneghat in the Western Ghats. A large number of tanks were cut in the rocks to provide drinking water to tradesmen who used to travel along this ancient trade route. Each fort had its own water harvesting and storage system in the form of rock-cut cisterns, ponds, tanks, and wells that are still in use today. A large number of forts like Raigad had tanks that supplied water.
- Underground baked earthen pipes and tunnels to maintain the flow of water and to transport it to distant places are still functional at Burhanpur in Madhya Pradesh, Golkunda and Bijapur in Karnataka, and Aurangabad in Maharashtra.
- Over two thousand years ago, a thriving city grew in the Arabian Desert—the ancient mountain city of Petra in southern Jordan. Despite the region's harsh climate, where the average rainfall is very low, the citizens of Petra, the Nabateans, learned to cope with little water. They knew how to harvest and conserve their water. A huge network of small reservoirs, dykes, channels, and cisterns enabled them to transport water into their city and to their fields. Hardly a drop was wasted. Their wells and cisterns were so well built that the Bedouin use them till this day. Some of the water conservation methods followed by the Nabateans, are helping farmers in the

drought-plagued Sahel states of Africa. (Sudan, Libya, the Niger, Burkina Faso, Mali, Gambia, Eritrea, Chad, and the Central African Republic are the Sahel states, along with Egypt, Morocco, Tunisia, and Nigeria, which were nominated to join.)

- In ancient times, houses in parts of western Rajasthan were built in such a manner that each had a rooftop water harvesting system. Rainwater from these rooftops was directed into underground tanks. This system can be seen even today in all the forts, palaces, and houses in the region.
- Archaeological evidence of water harvesting structures can be seen in the Middle East, in Jordan, Syria, Iraq, the Niger, and the Arabian Peninsula, especially Yemen. In Jordan, there are remains of early water harvesting structures believed to have been constructed over 9000 years ago.
- Hippocrates, known as the father of medicine, directed people in Greece to boil and strain water before drinking it.
- The *Atharvaveda* has a stanza that means: *Let us have the life-sustaining water through good conduct and proper means* (adequate resources). This sums up what our ancestors had followed.

Rainwater harvesting

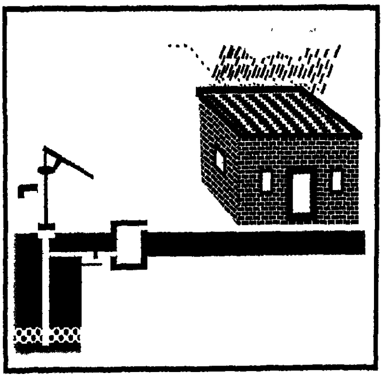
Rainwater harvesting means collecting and putting to maximum use of rain when it falls on land or some surface, allowing little time for loss due to evaporation or run-off. During the seasonal monsoon, there is plenty of water everywhere flooding villages and towns, but not enough of that water soaks into the ground. Rainwater harvesting, in effect, puts water back into the soil where it is directed into aquifers or stored in reservoirs to be taken out when needed for various household activities or to water plants.

Some benefits of rainwater harvesting

- Increases water availability
- Checks the declining water table
- Is environmentally friendly
- Improves the quality of groundwater through dilution, mainly of fluoride, nitrates, and salinity
- Prevents soil erosion and flooding, especially in urban areas

In urban areas, construction of houses, footpaths, and roads have left little exposed earth for water to soak in. In parts of the rural areas of India, flood water quickly flows to the rivers, which then dry up soon after the rains stop. If this water can be held back, it has a chance to soak into the ground and recharge the groundwater supply. This would help raise the level of water in the aquifers and thereby in the wells.

In cities, rainwater harvesting is merely collecting rainwater from rooftops in tanks for later use or to recharge the water table. This also prevents soil erosion.



Efforts have been made to collect water by building dams and reservoirs, and creating groundwater structures such as wells. Some countries have also tried to recycle and desalinate sea water. Techniques for constructing wells, underground tanks, roof water harvesting, and network of ponds and tanks have been developed in many parts of the world.

All you need for a water harvesting system is rain, and a place to collect it! Typically, rainwater is collected on rooftops and other surfaces, and the water is carried down to where it can be used immediately or stored. You can direct water run-off from this surface to plants, trees or lawns, or even to the aquifer. Not only does this arrest groundwater depletion, it also raises the declining water table and can help improve water supply. Rainwater harvesting and artificial recharging of the water table have become a necessity.

Tanks

In India's arid and semi-arid areas, the 'tank' system is the traditional backbone of agricultural production. Tanks are constructed either by building dams or by excavating the ground and collecting rainwater. This water is used for irrigation during dry periods.

Every Indian state has a great history of tanks. It is estimated that there are more than 350 000 tanks in the country. Tanks were constructed in the catchment areas of cities that were not located near a river or a large lake. Rainwater or run-off would collect during the rains and be stored for the rest of the year in these tanks and lakes in urban and rural areas where water was not available all around the year. The city would get its water supply from these. As we have read earlier, the cities of the Indus Valley civilization too had a very well laid-out system of tanks that supplied them with water.

In southern India, the towns were built around a temple, which always had a tank at the centre. Wells were located in the tank, which served as a link with the aquifers. Festivals were organized around tanks; cleaning and de-silting the tanks were a part of the rituals. There were innumerable tanks dug by the rulers, most of which have been destroyed. In some areas, tank building by the ruler was considered a noble deed. The Cholas were well known for the construction of tanks in the state of Tamil Nadu. Indore's water needs were met by a large number of wells and tanks located all around the city. But, over the last few years, the tanks have gradually dried up, including the largest of them, the Yashwant Sagar Lake.

Quanat system in Persia

The *Quanat* system, a traditional technique of tapping groundwater originated in Persia about 3000 years back and is still in use today. An extensive system of *quanats* is still in use in Iran where more than 22 000 *quanats* with their 170 000 miles of underground tunnels deliver a large volume of water. It has made a garden of what would otherwise have been an uninhabitable desert. In the Sahara region, a number of oasis settlements are irrigated by *quanats*, and people still call the underground conduits 'Persian works'.

During the period between 4th and 3rd century BC, Persian rule extended from the Indus to the Nile and the *quanat* technique spread throughout the empire.

Tunnels were dug to bring mountain groundwater to the arid plains. In practice, a *quanat* consists of a series of vertical shafts in sloping ground, interconnected at the bottom by a tunnel with a gradient. The first shaft is usually sunk into a level below the groundwater table. Since the system is fed entirely by gravity, the need for pumps is eliminated.

A recently discovered book by Mohammed Karaji, a Persian scholar of the 10th century AD, has a chapter on *quanat* construction.

Now, much work is being done to repair and revive ancient water-saving systems, including rundown temple tanks.

Conservation of water in the agricultural sector is essential as water is necessary for the growth of plants and crops. Depleting water tables and a rise in salinity due to overuse of chemical fertilizers and pesticides have made matters serious. Various methods of water harvesting and recharging have been and are being applied all over the world to tackle the problem. In areas where rainfall is less and water is scarce, the local people have used simple techniques that are suited to their region and reduce the demand for water.

be exposed to fog and dew. The resulting water can be used for crops.

- Contour farming is adopted in hilly areas and in lowland areas for paddy fields. Farmers recognize the efficiency of contour-based systems for conserving soil and water.
- Salt-resistant varieties of crops have also been developed in recent times. Because these grow in saline areas, overall agricultural productivity is increased without making additional demand on freshwater sources. Thus, this is a good water conservation strategy.
  - Transfer of water from surplus areas to deficit areas by inter-linking various water systems through canals
  - Desalination technologies like distillation, electro-dialysis, and reverse osmosis
  - Use of efficient watering systems such as drip agriculture system and sprinklers that reduces water consumption by plants

Some activities to familiarize you with water concepts

Water mapping

Here is an interesting exercise that you can start at your home and take the results to your school to share with your friends. As you know now, with the rapid increase in the world's population, access to freshwater has declined. This relationship is evident in both industrialized and developing countries and in both arid and wet climates. Take a weekend off, and sit and chat with your family and friends. Keep the following points in mind while discussing with them.

- How long they have been staying in the neighbourhood?
- What the water situation was like when they started to live here?
- Was there ever a natural source of water there?
- If yes, what was its status?
- Since when have they started experiencing a water crisis?

- What is the quality and quantity of water they receive these days?
- What are the steps they have initiated to deal with this problem?
- How many new families have moved into the neighbourhood?

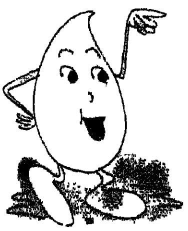
This exercise will allow the participants to get detailed information about the current status of water in their neighbourhood, and its past history. It will help them to understand how this precious resource is dynamic and needs to be monitored regularly. In the process, the direct relationship between population growth and water availability, will be analysed.

Water conservation

The most important step in the direction of finding solutions to issues of water and environmental conservation is to change people's attitudes and habits—this means each one of us. Conserve water because it is the right thing to do. Follow some of the simple things that have been listed below.

- Try to do one thing each day that will result in saving water. Don't worry if the savings are minimal—every drop counts! You *can* make a difference.
- Remember to use only the amount you actually need.
- Form a group of water-conscious people and encourage your friends and neighbours to be part of this group. Promote water conservation in community newsletters and on bulletin boards. Encourage your friends, neighbours, and co-workers to contribute.
- Encourage your family to keep looking for new ways to conserve water in and around your home.
- Make sure that your home is leak-free. Many homes have leaking pipes that go unnoticed.
- Do not leave the tap running while you are brushing your teeth or soaping your face.

- See that there are no leaks in the toilet tank. You can check this by adding colour to the tank. If there is a leak, colour will appear in the toilet bowl within 30 minutes. (Flush as soon as test is done, since food colouring may stain the tank.)
- Avoid flushing the toilet unnecessarily. Put a brick or any other device that occupies space to cut down on the amount of water needed for each flush.
- When washing the car, use water from a bucket and not a hose pipe.
- Do not throw away water that has been used for washing vegetables, rice, or dals, use it to water the plants or to clean the floors.
- You can store water in a variety of ways. A simple method is to place a drum on a raised platform directly under the rainwater collection source. You can also collect water in a bucket during the rainy season.



Worldwide initiatives

I chatter, chatter as I flow
To join the brimming river,
For men may come and men may go,
But I go on forever.

Lord Tennyson, The Brook, 1887

Initiative at the national and international level

2003 is the UN Year of Freshwater. It is a year for us to focus our attention on protecting and conserving our water resources, at our personal level as well as at the community, national, and global levels. By protecting our freshwater, we help ensure our future, and our planet's long-term prospects.

Over the years, a large number of initiatives have been taken at the international level to provide safe drinking water to all.

June 1972: UN Conference on the Human Environment, Stockholm, Sweden

In Recommendation 52, it has been clearly stated that the Secretary-General should take steps to ensure that appropriate United Nations bodies (WHO, FAO, etc.) support government action with regard to water resources where required.

Specialized centres should be established at the regional level in developing countries for training, research, and information exchange in cooperation with concerned United Nations Organization on

- inland water pollution and waste disposal,
- water management for rain-fed and irrigated agriculture, and
- integrated water resource planning and management.

1992 onwards annually: Stockholm Symposium – Water Quality Management, Stockholm

The Stockholm Water Symposium is an annual meeting on global water issues held during the World Water Week in Stockholm each August. After the first exploratory year, it has been focusing on a sequence of themes within two following areas.

1. Minimizing harmful fluxes from land to water (1991–1997)
2. Water as the key to socioeconomic development and quality of life (1998–2001).

It aims to develop practical solutions and strategies that will help alleviate the world water crisis. As an international conference for scientists, politicians, decision makers, and different stake-holders, this Symposium has promoted an understanding of global water problems. This understanding will help further cooperation in matters relating to preservation and protection of the Earth's water.

June 1997: Further implementation of Agenda 21 on Freshwater UN General Assembly Special Session – Earth Summit II, New York, USA

It is a matter of urgent concern that more than a fifth of all people still do not have access to safe drinking water and more than a half of humanity lacks adequate sanitation. There is growing concern regarding the increasing stress on water supplies caused by unsustainable use patterns, affecting both water quality and quantity, and the widespread lack of access to safe water supply and suitable sanitation in many developing countries. This calls for the highest priority to be given to the freshwater problem facing many regions, especially in the developing world.

1997: First World Water Forum, Marrakech, Morocco

The Marrakech Declaration stated that all member countries 'recognize the basic human needs to have access to clean water and sanitation, to establish an effective mechanism for management of shared waters, to support and preserve ecosystems, to encourage the efficient use of water...'. It was decided to establish 'The World Water Vision'.

March 1998: World Water Day, UNEP Freshwater Unit

The theme 'Groundwater—the Invisible Resource' was selected for 1998 as the UN system has expressed concern about three principal gaps in groundwater management, which have enormous implications for sustainable development.

March 2000: Second World Water Forum, The Hague, Holland

'The World Water Vision' was presented at this Forum and a 'Framework for Action' was proposed by the Global Water Partnership to achieve 'The World Water Vision'.

Some of the important points highlighted in this document are as follows.

- Involve all stakeholders in integrated management
- Increase public funding for research and innovation
- Increase cooperation in international water basins
- Massively increase investments in water

Seven challenges of the Hague Ministerial Declaration (2000)

- *Meeting basic needs* are essential to health and well-being and to empower people, especially women, through a participatory approach
- *Securing the food supply* and more efficient mobilization and use, and more equitable allocation of water for food production
- *Protecting ecosystems* to ensure their integrity through sustainable water resources management
- *Governing water wisely* to ensure good governance, so that involvement of public and interests of all stakeholders are included
- *Sharing water resources* to promote peaceful cooperation and develop synergies between different uses of water at all levels through river basin management
- *Managing risks* to provide security from floods, droughts, pollution, and water-related hazards

- *Valuing water* to manage water in a way that reflects its economic, social, environmental, and cultural values for all its uses, and to move towards pricing water services to reflect the cost of their provision

2001: International Conference on Freshwater, Bonn, Germany

The Ministerial Declaration stated, 'Combating poverty is the main challenge for achieving equitable and sustainable development, and water plays a vital role in relation to human health, livelihood, economic growth, as well as sustaining ecosystems.'

'The Bonn Keys' are points that highlight areas of necessary political attention.

- To meet the water security needs of the poor
- Local level is where national policy meets community needs
- The key to better water outreach is new partnerships
- Long-term harmony with nature and neighbours across water that touches many shores

2002 World Summit on Sustainable Development, Rio+10, Johannesburg, South Africa

The water and sanitation initiative at the WSSD (World Summit on Sustainable Development) approached water issues from a holistic perspective, outlining several key action areas, setting targets, and specifying activities to meet these targets. After the WSSD, the British Broadcasting Corporation hailed the water and sanitation initiative as the 'jewel in the summit's crown.' The water and sanitation target is to halve the number of people lacking access to safe drinking water and sanitation by 2015.

India

The Government of India has been taking legal action to ensure that safe water is available to all and have, since Independence, passed a large number of acts to facilitate this.

The River Boards Act, 1956

The River Boards Act, 1956, empowers the Central Government to establish, on request from the state governments, a River Board for advising them on matters concerning the regulation or development of an inter-state river or river valley.

The Inter-State Water Disputes Act, 1956

The Inter-State Water Disputes Act, 1956, enabled the creation of a Water Disputes Tribunal for settling water disputes that cannot be settled by negotiations with powers as are vested in a civil court under the Code of Civil Procedure, 1908. The Tribunal has the powers, or permit, to carry out necessary surveys and investigation.

The Accelerated Rural Water Supply Programme (1972/73)

The Accelerated Rural Water Supply Programme (1972/73) was introduced by the Government of India to assist the states and union territories to quicken the pace of coverage of drinking water supply in rural areas. The entire programme was given a boost with the launch of the technology mission called the Rajiv Gandhi National Drinking Water Mission and was put into action in 1995.

The Water (Prevention and Control of Pollution) Act, 1974

The Water (Prevention and Control of Pollution) Act, 1974, was passed to provide for the prevention and control of water pollution, and the maintenance and restoration of safe drinking water. The CPCB (Central Pollution Control Board) and the SPCBs (State Pollution Control Boards) were established under this Act. It empowers the SPCBs to maintain location and source-specific standards for discharge of waste water. The actual provisions for enforcement such as penalties, imprisonment, etc. are confined to source-specific standards for individual polluters.

The Water Cess Act, 1977

The Water Cess Act, 1977, empowers the SPCBs to levy a cess or tax on local authorities supplying water to consumers and on consumption of water for certain specified activities.

It also acts as a supplementary instrument for pollution abatement and provides for a rebate on the cess payable if the concerned local authority or industry installs a plant to treat sewage or trade effluent.

The National Water Resources Council, 1983

Headed by the Prime Minister, the National Water Resources Council prepares and reviews the National Water Policy, reviews water development plans and gives directions to carry out related studies, and advises practices and procedures for fair distribution and utilization of water resources in different regions and by different beneficiaries.

The Environment Protection Act, 1986

An umbrella Act providing for the protection and improvement of environment and for matters connected therewith, the Environment Protection Act authorizes the central government to intervene directly in order to protect the environment and also allows public interest litigation towards that end. The nature of penalties under this Act is similar to those authorized under the Water Act.

The National Lake Conservation Plan, 1993

The National Lake Conservation Plan focuses on urban lakes subjected to anthropogenic pressures and aims at prevention of pollution from point and non-point sources, treatment of the catchment area, etc. Twenty-one urban lakes have been identified for conservation of which 11 have been selected to be studied during the first phase of the programme.

The National River Conservation Directorate

The Central Ganga Authority established in 1985 under the chairmanship of the Prime Minister was re-designated the

National River Conservation Directorate in July 1995. It coordinates the implementation of schemes under the Ganga and other River Action Plans. These include works to intercept, divert, and treat waste water from all sources.

- The *Ganga Action Plan, Phase I,* aims at restoring the river water quality to the 'Bathing Class' standard.
- The *National River Conservation Plan,* launched in 1995, covers 18 major rivers in 10 states of the country. Under this action plan, pollution abatement works are being taken up in 46 towns in the states of Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, and Tamil Nadu.
- *Ganga Action Plan, Phase II,* takes up pollution abatement works in 29 towns. Of these, 10 are in Uttar Pradesh and 8 in West Bengal.
- *Damodar Action Plan* takes up pollution abatement works in 12 towns. Of these, eight are in Bihar and four in West Bengal.
- *Yamuna Action Plan* runs pollution abatement works in six towns of Haryana, eight towns of Uttar Pradesh, and in Delhi.
- *Gomti River Action Plan* undertakes pollution abatement works in Lucknow, Sultanpur, and Jaunpur in Uttar Pradesh.
- *The 73rd and 74th Constitutional Amendments (1992/93)* entrusted local bodies with responsibilities relating to water supply. The amendments also seek to ensure a better relationship between the state governments and urban local bodies.

The National Water Policy, 2002

- Accords top priority to drinking water supply in the allocation of water resources for various beneficial uses
- Addresses issues like the need for a well-developed information system for better resource planning, maximizing water availability, planning of water resource development projects, financial and physical sustainability of projects, participatory approach, private

sector participation, water quality, water zoning, water conservation, flood and drought management, and performance improvement; also calls for intensifying research in areas like assessment of water resources, hydrometeorology, water quality, water harvesting, and water losses

Glossary

Aquifer porous layer in the Earth's strata where water can be found

Elixir a remedy that can cure all
Ecology the branch of biology concerned with the relations between organisms and their environment
Encroach advance or go beyond the natural limits
Equilibrium maintaining a balance
Enteric of the intestine

Fissures a cleft or break in the ground through which water or lava flows

Industrial effluent waste discharged from industries
Ingression the action of going in or entering
Impermeable not allowing liquid to pass through

Leaching to remove a substance from a material, especially from earth, by the process of water moving through the material, to percolate or seep through (the ground)
Lagoon salt water lake separated from the sea by coral reefs or sand bars

Magma hot liquid rock found just below the surface of the Earth
Metabolism process by which living matter is broken down

Percolation the slow process of a liquid passing through a filtering medium; (for example, *the percolation of water through the soil*)
Prolific producing much or many